ANNUAL REPORT SUBMITTED TO: C/o Caitlin Simpson, Program Manager
Office of Global Programs
Human Dimensions Program
National Oceanic and Atmospheric Administration
1100 Wayne Avenue, Suite 1225
Silver Spring, Maryland 20910

LEAD OFF INSTITUTION: Indiana University

TITLE: HUMAN STRATEGIES FOR COPING WITH ENSO AND THE GROWING FLAMMABILITY OF FORESTS IN AMAZÔNIA

Grant No. NA06GP0344

PERIOD OF PERFORMANCE: July 2000 to March 2001

DATE SUBMITTED: March 28, 2001

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Summary of Project Goals:

This three-year project is undertaking an analysis of human coping strategies to ENSO-related drought, in light of the growing flammability of forests in two regions of the Brazilian Amazon. Recent studies had suggested that 60% or more of areas currently experiencing burning in the Brazilian Amazon burn unintentionally. In the past, tropical moist forests were sufficiently resistant to fire disturbance because closed canopies maintained high moisture levels in the understory, suppressing fire penetration at ground level. Fragmentation of forests, selective logging, and other anthropogenic driving forces have opened the canopy and created warmer and drier conditions at ground level that are more conducive to the spread of fire. This drying of forests is exacerbated during ENSO events. In the most recent El Niño (1997-98), researchers estimate that over half of forests that burnt in the Brazilian Amazon during that time were a product of the unintentional spread of fire due to extremely dry conditions. It is not widely recognized that Amazonian forests can catch fire. This misperception on the part of scientists, policy-makers, and forecasters could easily result in relevant information not being communicated to end-users. Our goal is to reconstruct the timing, content and dissemination of forecasts for the 1997-98 ENSO, trace household responses and evaluate land-cover change in order to improve dissemination and future use of forecasts, reduce socioeconomic losses due to drought, and minimize spread of fire into forests. A combination of social and environmental field research methods and analysis of remotely-sensed data are being used. Field methods include archival and survey research to reconstruct the history of land use and determine: 1) people's assessment of changing local fire spread and its relation to ENSO forecasts, 2) people's trust in the forecasts by source, 3) how the use of the forecasts was affected by fiscal policy and by the growing health risks from the heavy smoke from fires, 4) the changing economic value of forest in each area, and 5) to measure the extent of unintentional fire spread. Interviews with policy and decision-makers will assess their awareness of ENSO forecasts, and their understanding of their relevance for the study areas. Remotely-sensed data will be used to track changes in land cover, and changing land use as influenced by forecasts and changing moisture levels. The study will also examine the growth of cities in these two regions, and what role urbanization may play in exacerbating or ameliorating this situation. We selected a medium-sized city–Santarém (population~260,000) and a small city–Altamira (population~85,000) and their rural periphery as our study sites. The number of medium and small Amazonian cities has grown rapidly and they have notable importance in land-use and land-cover change because of growing rural-to-urban migration, and the growing proportion of urbanites' wealth in rural real estate. The process of assessment by individuals and groups as they organize to bring about reduced vulnerability to the consequences of ENSO events and to the spread of fire is of particular interest in this study.

The specific objectives of the proposed study are to:

(1) Study two field sites in the Brazilian Amazon in order to assess the accuracy of ENSO predictions in forecasting the regional patterns of precipitation and the risk of each area to the spread of fire;

(2) Identify coping strategies used by stakeholders to contend with ENSO events (including indigenous forecasting techniques) and the differential vulnerability of different groups of stakeholders;

(3) Assess the effects of ENSO events on vegetation, livestock, crops, and different social groupings in the two study regions;

(4) Understand the changing perceptions, and trust in, the forecasts by land users and urban dwellers in small and medium-sized cities, and whether they relate these forecasts' relevance to economic and environmental losses and health risks; and

(5) Develop improved ways to reduce vulnerability of most at-risk groups by bringing stakeholders, forecasters and policy-makers together to discuss this study's findings and implement local ENSO monitoring.

No changes in project goals have taken place to date.

Report of the first nine months' activities:

Because NOAA funds were not available until the end of the summer, we undertook a more modest first field season in 2000 than planned. This was probably for the best, since we found out a great deal of information that resulted in changes in the way we will sample from the population in the region, and that alerted us to many important questions that resulted in changes in the survey instrument to be used in summer 2001 and 2002. We traveled to Santarem to collect training samples to assist us in improving our land cover classification, and carried out archival research at various libraries, private collections, and government agencies. In addition we pre-tested our interview protocol with 14 households and made modifications after each three of them until we were satisfied that we were capturing the responses needed to meet the project's needs. We carried a small portable scanner that was very effective in copying maps, newspaper accounts and even tabular data. We also combined the collection of GPS data and training samples with visits to farmers along the way to get an understanding of their land use and settlement history which resulted in modification of how we will sample households during 2001. We found very distinct histories of land settlement and land use in the communities of Sao Jorge, Mojui dos Campos, and Belterra that we will try to capture fully during the survey research but that we began to explore during our informal interviews. To do this we had prepared images for 1999 acquired only a few days before fieldwork, and prepared them for use in the field by georeferencing them to a cartographic base. As noted below, fortunately we had the benefit of a careful analysis of a 1997 Landsat TM image carried out by one of our doctoral students as part of her dissertation on an adjacent region. Valuable maps were obtained from a variety of agencies that not only gave us a sense of what they knew about the region but that in some cases added to the data we could incorporate into our analyses.

Team members participated in meetings with scholars, association (NGOs, Unions) and institutions operating in the Santarém area. Among the important ones were the federal, state and municipal health agencies, Projeto Saude e Alegria, BASA or Development Bank for the Amazon, and the Sindicato de Trabalhadores Rurais de Belterra. These meetings allowed exchange of information valuable in planning the future course of the work. We were happy to collaborate in questionnaire development with a young Brazilian scholar, Ms Larissa Chermont, pursuing a Ph.D. at the London School of Economics with interests on the economics of fire use. Our meetings led to a joint effort in using some of the same questions about fire in both of our respective surveys, so that our sample and hers would have a greater total sample of households and could lead to joint publications. We have invited her to Indiana University this Spring for three weeks to further cement our collaboration and data exchange. She arrived this past week. Several team members took part in the collection of archival information in hospitals, in the Biblioteca Sena, and at the local office of EMBRAPA where we met with great collaboration and interest. They shared with us their daily rainfall, temperature and humidity records from the Belterra experimental station for the past decade. Unfortunately, they were paper records and we have invested in converting these records to electronic files and sharing these records back with EMBRAPA to assist their efforts. Exploratory fieldwork was particularly important for testing the questionnaire. In the field several iterations of the questionnaire were tested with informants, as well as with members of a farmers' union.

Upon return from the field, team members converted field notes and written health statistics into digital format to be posted on an intra-net created exclusively for this NOAA project to facilitate communication among the co-PIs and the graduate student assistants participating. This is particularly useful since one of the CO-PIs is in Los Angeles. This has allowed a steady communication and mutual querying about information obtained by different members of the team. We also developed rules for co-authorship so that this information is always associated with its source and use of such data is governed by collegial respect for intellectual property. We also carried out data quality checks on the health statistics and posted the health statistics relevant to our study. The articles, statistics, maps, transcripts, and tables that were scanned in Santarem were also converted to a digital format (.pdf or .html) that could posted on the intranet for dissemination to all the members of the research group.

With the training sample information obtained in the field we ran an accuracy assessment on the classification of the 1997 image of Santarém. We also extracted some signature files from the areas of interest to be used in a hybrid classification of the 1999 image. We began working on the radiometric

calibration of the 1999 Santarém image. We have run a preliminary supervised classification of the 1999 image utilizing the signatures extracted from the AOI layer, and run a number of other classifications on the 1999 image using the
saved signature files that were used to classify the 1997 image. This work was much accelerated due to the experience of one of our Center's doctoral students, Ms Celia Futemma, who had done work in a region just north of our study area. This gave us access to her Landsat images for 1986 and 1997 and her familiarity with the landscape allowed her to extrapolate her signatures for different land cover classes to the entire study area of this project. While she was uncertain whether the extrapolation would work out, our collection of training samples gave it an accuracy of around 90% for most land cover classes. After fieldwork, all the ground truth data was entered into Imagine software for purposes of future image analysis. Thus, all the information collected and processed thus far serves the basis for carrying out analysis across space and time in order to answer specific questions on climate change and patterns of land use. Finally during fall of 2000, we searched for more images from 2000, 1970s, and 1980s, to carry out historical analysis of change in land use and land coverage and their relation to climate change and El Niño occurrence.

As a team we are also developing other GIS coverages that include basic infrastructure (i.e. roads), river networks, town locations, and the creation of Digital Terrain Models (DTMs) derived from interpolated elevation values. The DTMs will be important when used with classified imagery for modeling potential fire and its impact in the region. Combined with the property grid it will be possible to model the impact and potential impact of fire on individual farm properties over time.

Following the pre-test, team members went through the questionnaire for the household head's making adjustments based on information derived form fieldwork. Particular attention was given to developing a questionnaire, which allows the collection of accurate information for analysis, and enhances the efficiency of data entry, reduces errors in data entry, and comparison between our two study areas. The final product consists of 140 questions divided in six main sections :

1) General: characteristics of male household and his relationships to the lot.
2) Characteristics of the Lot: information of land use in general.
3) El Niño: perception and reactions.
4) Land Use: fire use and fire management.
5) Labor and Technology.
6) Social Organization and Credit.

We also have a questionnaire for the female head of the household mainly based on the questionnaire used in an earlier study on demographic dimensions of deforestation. We have radically simplified this very extensive demographic instrument to meet the needs of this project. It aims to collect information on the age and gender structure of households, and on the reproductive history of the women in the household. Other questions will be introduced to capture a picture of the household economy and as a check on the information obtained from the male head of household. We have completed modification, therefore, of both the male and female head of household questionnaires, developed a database for facilitating the data entry, and drawn our stratified random sample so that it captures the differences over time in the land use developments in the region. To do so a software application has been constructed to facilitate encoding, validation, and retrieval of questionnaire data. Validation of data, based either on its format or its deviation from the distribution of current entries, helps to eliminate errors in data entry. Retrieval of the data may be carried out on a record by record basis or by user specified datasets. This application stores information about each of the questions for potentially several questionnaires and the responses to each for each household. It is ready to be deployed over a network as several clients with a common back end data storage. This application includes both a native GIS interface with ESRI ArcView to permit either simple orientation of the user or analysis.

Preliminary Insights:

Since we have not yet carried out the extensive survey research, what we have to date are preliminary insights based upon the interviews with TV and radio personnel, archival work on newspapers and

documents, and discussions with local farmers and officials. It appears at this time that there is a minimum of weather information transmitted to the local population in Santarem. We found no local weather forecast information provided by newspapers, radio or television. The only weather forecast provided is that of the national TV network which provides a very general Amazon-wide daily forecast that bears little resemblance to local weather. We did find newspaper stories that told us of the severity of El Niño in 1997-98, the destruction of some areas of forest, and of the low level of the hydroelectric reservoir that resulted in regular blackouts to the urban population due to lack of energy generating capacity. Interestingly, we also found in our research on the local newspapers that the previous year had been characterized by spectacularly high rainfall and flooding. This may have provided some protection during the early stages of El Niño masking the impact of the drought. However, in the late stages it was regularly reported that the fire department had to be called to quench fires on some properties near the city, and the national forest FLONA experienced some large fires within its confines. We also found considerable lack of trust in the official forecasts (not surprising given its lack of local relevance), but also the presence of some local systems of forecasting. In our interviews we will be looking to discover more of these ethnoecological methods for forecasting precipitation. We have found that people lost large areas of valuable planted crops to the spread of fire from one property to the next and we will be trying to quantify this during the survey research, and to inquire whether these losses can be prevented. We also discovered that there is a move to convert up to 500,000 hectares of "degraded forest" at least into soybean fields. Soybeans seem to be moving from Mato Grosso and Parana into the Amazon and the corridor along the Cuiaba-Santatem road which is in process of being paved, will be linked to an improvement in the Santarem port that can reduce the cost of exporting soybeans by 60 cents a ton. If this occurs one can expect greater deforestation and greater economic losses during ENSO events.

Plans for Year Two:

Because funds were not released in a timely fashion, we were not able to undertake the survey research during our first fieldwork season in 2000 as planned in the original proposal. Instead, we limited ourselves to designing and pre-testing the survey instrument on 14 households, and in collecting archival information and meeting local collaborators. While in the field in summer 2000 we obtained a very large map with the properties' boundaries from INCRA, the resettlement agency. We have now digitized this property grid and are in process of geocorrecting this before field research. This grid provides a basis for drawing our sample. During summer fieldwork in 2001 we will collect half of our sample at both research sites. Between now and fieldwork we are engaged in the preparation of field materials including image processing and printing to facilitate field assessment of land cover and final preparation of the survey questionnaires. We will carry out interviews with small farmers and participants in local institutions (governmental and non-governmental) and other key individuals and officials particularly those relevant to the transmission of forecasts to the population.

We plan to sample at least 80 households at each of the two sites (N=160). The 80 households in Altamira will be selected from a stratified random sample based upon arrival time that we have developed for this region that allows us to distinguish between cohort and period effects, as well as the role of time since deforestation began. The 80 households in Santarem will be randomly chosen from a stratification based upon differential history of occupation based upon the preliminary fieldwork carried out in 2000 and the acquisition of a property grid that allows us to draw our sample based on spatial distribution along these roads which represent different times of occupation and differences in land use. We will use a team of four pairs of interviewers, each one made up of a man and a woman to make it feasible to have a separate interview with the male and the female heads of households to fully explore the land use and labor dimensions of farm management, and the use of fire by the household over time. Based upon our pre-test work in 2000, we expect each team to be able to carry out two household interviews per day, in addition to visiting the property to spatially locate features of the land use using a GPS and to check the accuracy of our land cover classification and the veracity of the responses from the interviews. This more relaxed walk through the farm can also provide important information on folk systems of forecasting and attitudes towards the official forecasts.

Upon return from the field, the survey data will be entered into a database grid that has already been

developed with a view to beginning analysis of this first half of the survey data during the academic year. This data and sample will be of sufficient size to permit us to begin publishing results and presenting papers at professional meetings. We already have several invitations to present results from our work at meetings both here and abroad. We expect to return to the field in 2002 to carry out the additional 160 survey at both sites.

Differences in perception between rural and urban residents will be examined, as will their changing strategies over time and space. It is assumed that greater measures may be taken to prevent fires as one gets closer to the city. Whether this is true, or whether the wind patterns make such practices ineffective will be examined. Both cities' airports have experienced closings due to smoke from fires, and health risks have been noted by local physicians due to pervasive smoke for many consecutive days. Data collected on changes in respiratory ailments during El Niño years from the public health service, hospital, and other local agencies responsible for maintaining health records will be examined to look for trends during ENSO and non-ENSO years.

Significance of the study:

One of the challenges of global change research is to make scientific information more relevant to decision-makers at the local and regional level. This study has already begun to engage local actors (NGOs, government agencies, TV and other local media, information "brokers", and individual land users) in the process of evaluating the use of climate forecasts. All those interviewed expressed surprise when they discovered that the "other" agency also had not transmitted a local forecast. It seems each media source assumed another media was doing so! The 1997-98 ENSO is the focus of attention, but other forecasts are being used in assessing the use of information. In addition, experiments in focus groups will be conducted with the above local informants to see how severity, magnitude, and other characteristics of the forecast influence their propensity to make different decisions about the use of fire, the use of land, and other economically relevant strategies (e.g. sell cattle, not harvest crops). The impact of drought is mediated by access to adaptive technologies, crop prices, subsidies and insurance. Access to these adaptations is highly variable by region, sector, and social group. Smallholders, for example, have been noted to lack the financial and technological means to make firebreaks, but some of them do– why? ENSO can be forecast with three to twelve-month advance notice, and the potential impacts of ENSO on agriculture, health, water resources, and fire can be evaluated before, during and after the event. Since the Altamira-Santarém region is considered a particularly important agropastoral production zone, a goal of the study is to evaluate how well decision-makers use available information and adaptive technologies to reduce vulnerability of people in the region. Does the size of the city influence the flow of information or trust in it? Are the dominant crops particularly vulnerable to precipitation shortfalls (pasture vs tree crops)? Does one region have a more effective method of delivering climate forecast information than the other? Are special fiscal instruments made available in a timely fashion to reduce risks to all, or only some, stakeholders?

A key to making climate prediction more socially useful lies in how one develops link between those who produce the forecasts and those who benefit from the forecasts. The users need to be engaged in this process, and this becomes a serious challenge in an area such as Amazônia with proverbially poor road infrastructure, and wide gaps in education and economic status. It is hypothesized, that urban merchants who own rural properties will not necessarily be the first to hear the forecast of an oncoming el Niño, but that they will be the first to take coping strategies because of their greater trust in the forecast, the likelihood that they would lose the most from the spread of fires, and their greater capability to shift production priorities because of greater total wealth. Small rural producers will vary in their response to the forecast. Those with young families are less likely to shift production strategies than older household heads because of the lack of capital, as compared with the greater flexibility and modest capital available to older households whose cropping strategy is more diversified to start with. As part of this study we will seek, in year three, to bring the forecasting community together with the user communities to undertake a process of mutual education and discussion as to how best to transmit the information needed by each group in a workshop. This will go a long way to make the results of the study result in changes in how forecasts are used by people of these two regions, and others like it. Jointly we would seek to develop an El Niño Prediction Kit that would cost-effectively engage local stakeholders in monitoring the magnitude and risk

of future ENSO-related droughts.

Subcontract: C. Sorrensen, who has collaborated with us in the past, and who recently took up a position at Cal State Univ. in Los Angeles has a subcontract with us to ensure her participation in the project. She has experience in the Santarem region, and has studied the use of fire as a management strategy in that region. She went to the field with us and fully participated in the fieldwork and statements made above with regards to the team's work should be taken to include her as well.